THE PLANT SUCCESSIONS OF THE HOLYOKE RANGE

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 198

EDITH A. ROBERTS

(WITH MAP)

Introduction

The Holyoke Range lies well within the eastern deciduous forest region with the climatic plant formation of the mesophytic deciduous climax type made up of *Acer saccharum* (sugar maple), *Fagus grandifolia* (beech), and *Tsuga canadensis* (hemlock). The range is located nearly in the center of the Connecticut valley, which crosses the state of Massachusetts from north to south and varies from 100 to 1200 feet in elevation. The many topographical features offer opportunity for the study of the development of the vegetative cycles terminating in the climax forest of central Massachusetts.

A few isolated portions which have been uncut for over 250 years furnish evidence as to the climax, while the repeated cutting in other places gives excellent opportunity to study the development of the so-called "secondary succession" (1), a study which will of necessity be more valuable as the work of reforesting increases, especially in the New England states, where the future forests will for the most part be of that type.

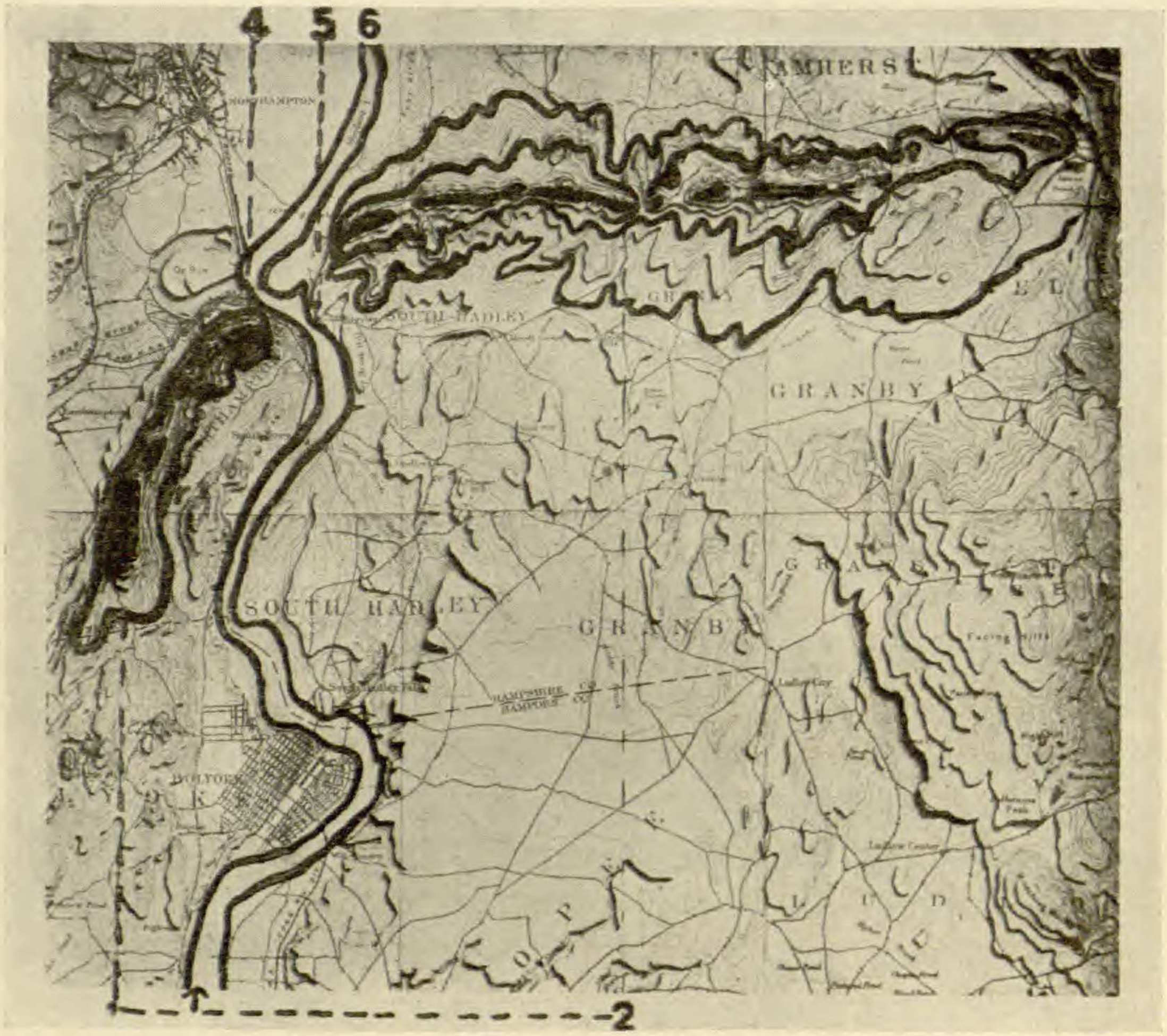
The purpose of the work is to determine the varying lines of biotic successions leading to the present climax in this region, and in a later paper to determine the relationship of the factors which are influencing these successions.

The region is typical of the central portion of the state and the range represents a natural unit which, owing to its direction (see map), offers opportunity to study north, south, east, and west slopes, with their variations in succession.

The work was begun at the suggestion of Dr. HENRY C. COWLES, of the University of Chicago, and I wish to express my thanks for his suggestions and interest in the work. I wish to thank Miss MIGNON TALBOT, of Mount Holyoke College, for the material on

the topography and physiography of the region, and Miss SARAH J. AGARD, of the botany department, for identification of uncertain species.

The nomenclature of the pteridophytes and spermatophytes is that of the seventh edition of GRAY'S *Manual*.



MAP.—1, Mount Tom Range; 2, Mount Holyoke Range; 3, Holyoke Range; 4, Nonotuck; 5, Titan's Pier; 6, Connecticut River.

Topography and physiographic history

The Holyoke Range is situated in the western central part of Massachusetts in lat. 42° N., long. 70°30′ W., in an old river valley. The range varies in elevation from 100 feet to 1200 feet and is 10 miles in length.

The valley was carved out by stream erosion upon a great thickness of sandstone, conglomerates, and shales with interbedded lavas; the main sheet of which, and the one which caps the ridges,

is the Holyoke diabase. These Triassic rocks were later subjected to tilting, warping, and faulting, and these processes, together with stream erosion, resulted in the formation of the "trap" ridges which stand above the valley floor with steep cliffs facing the west or the north, as the case may be, and more gentle slopes on the east and the south, slopes that are practically that of the dip of the rocks. These cliffs are in places 600 feet high and in others are almost buried by the accumulation of talus and glacial débris. There are numerous faults running north and south, in general crossing the Holyoke Range at right angles and running almost parallel with the Mount Tom Range.

During the ice age the ice sheet passed over the region and left much glacial material on the north side of the range. As the ice retreated north a lake was formed here and another one on the south side. The one north of the range was called the Hadley Lake and the one south, the Springfield Lake.

The Hadley Lake found an outlet between Nonotuck and Titan's Pier (see map). Today the area is drained by the Connecticut River, which doubtless has occupied different portions of the lake bed, but now is cutting close to the east side of the Mount Tom Range (see map).

The region is being acted upon but little by stream erosion, as the streams are of small size. On the south side of the Mount Holyoke Range there formerly were 20 streams originating at an elevation of 400–500 feet, while on the north side there were 6 at that height. The many streams on the south side of the range were doing active erosion work along the fault lines, but the frequent deforestation has been instrumental in exhausting the streams, and as a result there are many ravines, young topographically but quite old floristically.

On the north side of the Mount Holyoke Range there are wide crevices in the cliff face due to the presence of faults, but below the cliff face the mountain side presents a uniform mass of talus and glacial débris. Along the talus below the wide crevices there is always a greater amount of moisture, where more of the "run off" on the north side of the range sinks into the talus than along the talus at the foot of the unbroken cliff face.

There is little bare rock exposed except on the cliff faces and at the edges of the highest peaks; there weathering is playing an active part. Small and large flakes of the trap rock are being split from the face. A great many of them pile up at the top of the talus slope and furnish splendid agents for catching the finer material which is washed down.

The vegetation is playing an active part in changing the physiographic features of the region.

Classification of successions

The initial biotic vegetative cycles are so determined by the original xerophytic and hydrophytic habitats, that I have classified the xerarch (1) and hydrarch successions in topographic terms as follows:

I. Xerarch successions: (1) trap slope successions; (2) trap cliff successions; (3) talus successions.

II. Hydrarch successions: (1) ravine successions; (2) brook successions.

All the region except the brooks has passed through several of the successions leading to the climax forest, and a small area is now in the beech-maple climax, which is the culminating stage of the region, while a little to the west of the range the hemlock forms the climax. There is, however, in this region some indication of the hemlock coming in as a climax type.

It is doubtful if there is any climax representing that of the so-called primary succession, which might well be called the initial succession. The region represents a third or fourth attempt to develop a climax forest, as do most of the New England forest areas. These successions have been called secondary successions, but might better be called repetitive successions, because the deforestation causes the area to revert to an aspect which is a combination of a former succession with the successions which ordinarily follow it. The term "secondary" does not carry with it the idea of more than one attempt at repetition, while "repetitive" indicates no limit in the number of attempts.

Mount Tom has been a state reservation for 10 years, and since then has been free from the retarding and retrogressing factor, man.

This biotic influence has interrupted successions on every topographic type, chiefly in the following ways: cutting, with or without burning, followed by cultivation, pasturing, or permitting the area to become of economic value without assistance from man.

This always retards the development of the area temporarily, although it soon assumes the aspect of some previously established type, modified by the interpolation of certain species, and it retains, unless burned over, remnants of the previously established types, especially among the herbs. These are of aid in the determination of the history of the region in regard to the activities of men and plants.

The plants are listed here under the great groups, making it possible to bear out NICHOLS' (3) statement that "species in groups of comparatively recent evolutionary derivation are far more restricted in range than species in groups of more recent origin." The spermatophytes are again divided into trees, shrubs, and herbs, to indicate more clearly the difference in biotic influence.

Xerarch successions

TRAP SLOPE

There is an east face and a south face; the former belongs to the Mount Tom Range, which has been a state reservation for 10 years, and which, it is hoped, will some day afford an opportunity of seeing in this region a climax forest of some extent.

There is no difference in the two slopes aside from the presence on the south face of more ravines; in these ravines cutting has ceased, as deforestation followed by fire has caused the drying up of streams, leaving the ravines young topographically. The entire region has been cut over within the last 25 years. At the top the vegetation is again getting a foothold on the rock outcrop, except at the edge, along the fault lines; here there is young tree growth, in which can be found old stumps of red oak three feet in diameter, indicating how far the region had progressed in its development.

On the rock outcrop are found the following:

Spermatophyta: Herbs.—*Carex rosea*, *Aquilegia canadensis*, *Corydalis sempervirens*, *Arabis Drummondi*, *Saxifraga virginiensis*, *Arctostaphylos Uva-ursi*, *Cardamine parviflora*.

Pteridophyta: *Woodsia Ilvensis, Selaginella rupestris.*
Bryophyta: *Umbilicaria* sp., *Ceratodon purpurea, Physcia* sp.
A few feet below the rock outcrop are found the following:
Spermatophyta: Trees.—*Juniperus virginiana, Carya alba, C. ovata, Quercus alba, Q. rubra, Q. Prinus.* Shrubs.—*Quercus prinoides, Amelanchier canadensis, Pyrus arbutifolia, Cornus circinata, Vaccinium stamineum, V. cassinoides.* Herbs.—*Maianthemum canadense, Polygonatum biflorum, Hypoxis hirsuta.* New ferns are *Aspidium marginale, Polypodium vulgare,* and *Polystichum acrostichoides.*

Where the faults are at right angles to the range, the rock cliff has been worn away and the edges take on a rounded form. Here the trees have been established longer and are about three inches in diameter. There is found the same grouping as is found a hundred feet below the top of the trap rock slope, with the addition of *Castanea dentata* and *Acer saccharum* as seedlings. The new shrubs are *Diervilla Lonicera* and *Viburnum acerifolium,* while the spermatophytic herbs are *Uvularia perfoliata, Thalictrum dioicum, Hepatica triloba, Anemone quinquefolia,* and *Aralia nudicaulis.* The ferns are *Pteris aquilina, Asplenium Trichomanes,* and *Cystopteris bulbifera.*

The lower half of the slope, though cut at the same time, has advanced much more rapidly. Wherever there is a trap rock outcrop the bryophyte and pteridophyte vegetation is found, and about it the spermatophytes just mentioned, but the trees are larger and the following additional species have come in: *Fagus grandifolia* as a seedling, with occasional plants of *Tilia americana* and *Fraxinus americana.* The shrubs are *Hamamelis virginiana, Dirca palustris, Cornus florida,* and *Viburnum dentatum.* Characteristic spermatophytic herbs are *Arisaema triphyllum, Habenaria Hookeri, Habenaria bracteata, Actaea rubra, Pyrola elliptica, Lysimachia quadrifolia, Orobanche uniflora.* The ferns are *Pteris aquilina, Polystichum acrostichoides, Dicksonia punctilobula,* and *Asplenium acrostichoides.*

The base of the trap slope has now on it every type of repetitive succession except that of cut-over beech forests. Places untouched for the longest time show the dominance of chestnut. Red oak and

white oak stumps 4 feet and 5.5 feet in diameter indicate that the region was allowed to pass at least through the oak succession, and chestnut 2 feet in diameter with hard maple 1 inch in diameter show that it is the day of the chestnut with the promise of hard maple later. Old landmarks of hard maple and chestnut give evidence of a previous attainment of that stage of succession, which appears to be the temporary climax of the east and south slopes.

TRAP CLIFF

The cliff is of greater height on the west side of Mount Tom than on the north side of Mount Holyoke. The numerous faults on Mount Holyoke run at right angles to the range, and the more active erosion along the fault lines increases the amount of talus. This, in addition to the glacial drift deposited on the north side, accounts for the talus reaching the top of the mountain and burying the cliff face, except for short spaces between the fault lines. On Mount Tom the faults are fewer and run parallel with the cliff face, and the glacier left no deposit except at the Nonotuck end (see map).

A lichen flora, yet undetermined, is established on most of the cliff, *Umbilicaria* playing a conspicuous part. The rock flakes off so rapidly that it is doubtful if any later vegetation is established. Often before the lichens are established the rock flakes off and is added to the talus below. The talus is made up of large flakes with or without lichens upon them.

The crevices and shelves afford a more permanent foothold and conifers have become established here, so that from a distance the mountain side appears to be rather well covered with trees.

The following species are found in crevices, and on shelves of the east-facing cliff: Spermatophyta: Trees.—*Juniperus virginiana, Pinus Strobus, Pinus resinosa, Tsuga canadensis.* Herbs.—*Saxifraga virginiensis, Corydalis sempervirens, Campanula rotundifolia.* Pteridophyta: *Woodsia Ilvensis, Asplenium Ruta-muraria.* Bryophyta: *Hedwigia albicans, Grimmia apocarpa.*

The cliff represents, if do any of the regions, the first of the initial successions. The first stages in the group of initial successions on the north face and the east face are the same, but the second stages are different. The many shelves found on the east side offer

a place for more rapid accumulation of soil; junipers, pines, and grey birches come in, while on the north face *Tsuga canadensis* gets a foothold in the crevices.

The pines and the hemlock seem to represent a temporary climax until the edaphic situation becomes altered.

TALUS SUCCESSION

At the west side of the Mount Tom Range the talus is made up of trap flakes alone, while on the north side of the Mount Holyoke Range it is composed of trap and glacial drift. In each case trees and undergrowth are established on the entire talus except where patches of rapidly weathering rock have covered all but tree growth; in such places birch or butternut may be seen growing in the midst of an island of trap chips. At the base of Mount Holyoke, where the glacial drift is associated with trap chips, the soil is far more stable and is covered with herbaceous forms.

Shrubs and vines advance up the slope at the base of the cliff, with the assistance of a little lichen or moss growth. At the top of the talus, which is made up of clean trap chips, an interesting advance is made by the plants with creeping stems and rootstocks, *Rhus Toxicodendron*, *Psedera quinquefolia*, and *Vitis aestivalis*.

The talus on the north side of Mount Holyoke presents an almost unbroken slope except at the top. As the fault lines extend across the trap face, short ravines have been formed at the head of the ravines of the trap slope. Here the drainage divides to the north and south and the north face receives more moisture below these short ravines. This unequal amount of moisture together with the greater amount of shade, due to the projecting sides of the trap ravines, affects the vegetation for about 50 feet along each fault, and below this the talus assumes a uniform aspect.

In a short ravine facing north are found: Spermatophyta: trees over a foot and a half in diameter, *Tsuga canadensis*, *Betula alba*, *B. lutea*, and *B. lenta;* trees about an inch in diameter, *Ostrya virginiana*, *Quercus rubra*, *Q. alba*, and *Carya ovata;* there are a few seedlings of *Acer saccharum;* and scattering shrubs of *Hamamelis virginiana*, *Acer spicatum*, and *Viburnum acerifolium* are found. The spermatophytic herbs are *Maianthemum canadense*,

Senecio aureus, *Polygonatum commutatum*, *Aralia nudicaulis*, and *Mitchella repens*. The Pteridophyta are *Adiantum pedatum* and *Lycopodium lucidulum*.

Where the slope is uniform are found: *Betula lenta*, *B. alba*, *Juglans cinerea*, *Fraxinus americana*, *Quercus rubra*, *Q. alba*, *Q. Prinus*, *Carya alba*, and *Castanea dentata*, all over a foot in diameter. Old stumps of *Tsuga canadensis* and isolated specimens of *Pinus rigida* and *Pinus Strobus* tell of the history of the slope. *Acer saccharum* of small size prophesies the future of the slope if it is left to itself. The following shrubs, *Kalmia latifolia*, *Acer spicatum*, *Cornus florida*, evidence better conditions for growth, as do also the herbs *Uvularia perfoliata*, *Trientalis americana*, *Trillium erectum*, and *Maianthemum canadense*. The Pteridophyta are represented by *Adiantum pedatum*, *Osmunda cinnamomea*, *Dicksonia punctilobula*, and *Polystichum acrostichoides*.

The chestnut–red oak–white oak–hickory stages seem to be telescoped (2) on the north side, while on the south face the stages are distinct.

The talus on the north side below this grouping has much hard maple and many young beech trees 10 inches or more in diameter. Whether it is or is not a question of more frequent deforestation on the one side than on the other, it is true that the beech is far more common on the north side. In some places there are beech trees three feet in diameter with an undergrowth of young beech and hemlock; while on the east-facing talus and on the south-facing trap rock, as well as on the north, old stumps of hard maple and chestnut three feet in diameter are common, but there is no indication of beech coming in other than occasional one-inch saplings.

Herbs show a quicker reaction to environment and are more rapid indicators of changing conditions than trees. The spermatophytic herbs found near the base of the slope are *Uvularia perfoliata*, *Erythronium americanum*, *Trillium sessile*, *T. erectum*, *T. cernuum*, *Orchis spectabilis*, *Habenaria bracteata*, *Epipactis repens*, *Actaea rubra*, *Dicentra Cucullaria;* and the Pteridophyta, *Phegopteris Dryopteris*, *P. polypodioides*, *P. hexagonoptera*, *Adiantum pedatum*, *Aspidium spinulosum*, *Cystopteris fragilis*, and *Botrychium virginianum*.

There is an indication of the hemlock coming in twice in the succession, first in the early stages of the ravines as a temporary climax, and later at the climatic climax of the region as shown in the successions on the north talus slope. The white pine does much the same thing, forming a temporary climax on the east-facing cliffs and a temporary climax on the lake bottom sands, which are at the foot of the talus slope. There are many places just south of the range along the old lake shore where the pine remains established for some time. It looks as if the region had reached the pine stage many times; now conditions are such that the region is advancing a stage and oaks and chestnut are beginning to get a foothold. The accompanying diagram in a general way indicates the natural successions and the effect of repeated deforestation.

Hydrarch successions

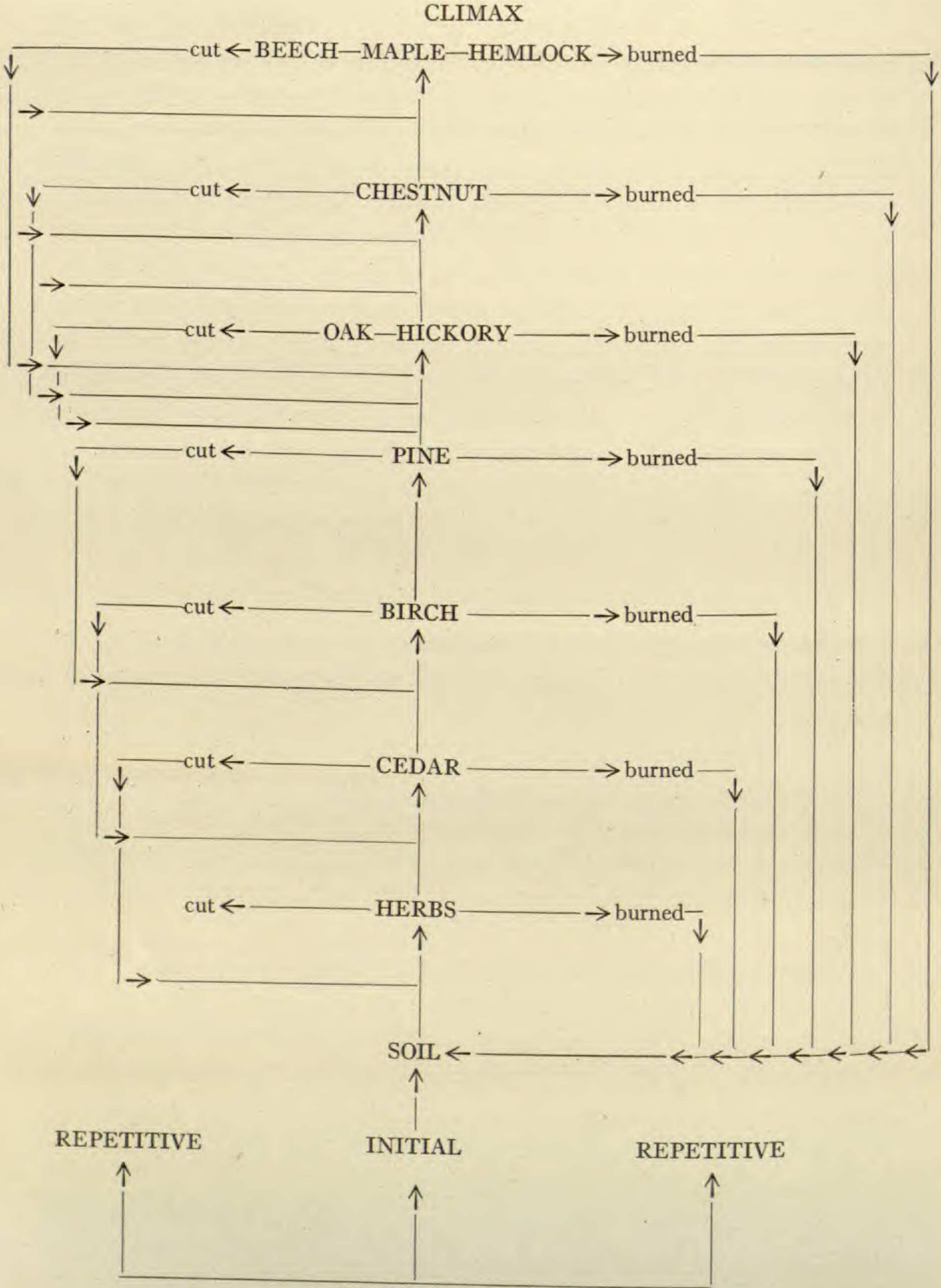
RAVINE SUCCESSIONS

The ravines parallel to the Mount Holyoke Range and the ravines on the south trap face of Mount Holyoke are to be considered.

The parallel ravines on Mount Tom have been formed by differential weathering and never had any streams in them. The rock sides are perpendicular and have no vegetation but lichens, except for a few crevice plants. The base of the ravine is covered with trap chips among which vines and a few shrubs are getting a foothold.

The ravines on the trap slope are no longer being actively cut. The rapidly repeated deforestation has exhausted many of the streams, so that there are found many ravines young topographically but old floristically. In the early spring the melting snows drain down these ravines. Other ravines are older topographically and have wide sides, which are the same floristically as the adjoining slope of the range at the same level.

In a ravine from which water has recently been withdrawn can be found *Tsuga canadensis*, *Pinus Strobus*, *Juglans einerea*, *Tilia americana*, *Betula lenta*, *B. lutea*, *Castanea dentata*, *Acer saccharum*, and some very young *Fagus grandifolia*. Time enough apparently


CLIMAX
cut ← BEECH—MAPLE—HEMLOCK → burned
cut ← CHESTNUT → burned
cut ← OAK—HICKORY → burned
cut ← PINE → burned
cut ← BIRCH → burned
cut ← CEDAR → burned
cut ← HERBS → burned
SOIL
REPETITIVE
INITIAL
REPETITIVE
SUCCESSIONS

has passed in the ravine formation to permit the passing of the succession to *Fagus grandifolia*.

A young ravine on the south side in which cutting has long since ceased contains many of the same forms showing a slow succession.

THE BROOK

The brooks are fast passing out of existence in the vicinity of the range, so that mention is made only of the plants found in the brook and on its immediate banks. The trees are *Ulmus americana* and *Acer rubrum;* the shrubs, *Alnus incana*, *Benzoin aestivale*, *Ilex verticillata*, *Vitis Labrusca*, *Cornus stolonifera*, and *Dirca palustris;* the herbs, *Thaspium aureum*, *Caltha palustris*, and *Symphoricarpus foetidus*. This is soon followed by a heavy growth of *Carpinus caroliniana*, with *Betula lutea*, *B. lenta*, and *Fraxinus americana*. These pave the way for oaks and hickories.

Summary

1. The region is a mountain range of trap rock.

2. The climax forest of the region is of the beech-maple-hemlock type.

3. The successions may be classified as:

I. Xerarch successions: (1) trap slope successions; (2) trap cliff successions; (3) talus successions.

II. Hydrarch successions: (1) ravine successions; (2) brook successions.

4. The terms initial and repetitive seem to be better than primary and secondary in conveying the idea of often-repeated successions such as are found in a frequently deforested area.

5. The east-facing and the south-facing trap slopes have the same successions. *Castanea dentata* seems to present a temporary climax.

6. The trap cliff doubtless presents an initial succession in which the east and north cliffs have similar first stages, but the second stage on the east is *Pinus Strobus* and *Pinus resinosa*, while on the north it is *Tsuga canadensis*.

7. The combination of weathered rock with glacial drift on the north talus slope affords a better opportunity for the climax formation than does rock alone on the talus east of Mount Tom.

8. Repeated deforestation has prevented all but a small area from reaching the climax.

WRIGHT LABORATORY
MOUNT HOLYOKE COLLEGE

LITERATURE CITED

1. COOPER, W. S., The climax forest of Isle Royale, Lake Superior, and its development. BOT. GAZ. **55**:1–44, 115–140, 189–235. 1913.
2. COWLES, H. C., The causes of vegetative cycles. BOT. GAZ. **51**:161–183. 1911.
3. NICHOLS, G. F., The vegetation of Connecticut. Torreya **13**:89–112. 1913.